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—— Les fortes chaleurs de juillet 1904 en France. [Note on article of G. Barbé.] Pp. 350-352.

—— Effets du sirocco. [Note.] P. 352.

—— Le climat de Panama. [Review of article of Wm. H. Burr.] Pp. 373-374.

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VORTEX RINGS AS REVOLVING SOLIDS.

By Dr. F. J. B. CORDEIRO, Surgeon U. S. Navy. Dated San Francisco, U. S. S. *Solace*, March 21, 1904.

It appears that my use of the smoke rings[1] as an illustration of the fact that a gas moving in a certain manner may become, for dynamical purposes, a solid was not satisfactory to the Editor. Permit me, therefore, to give another illustration, nay, a proof, that we may regard the cyclone as a revolving solid.

Suppose we coil a tube into a spiral, so as to imitate to any degree of approximation the flow of the currents of air in the cyclone, and suppose that, by means of flexible tubes, we permit a stream of water to enter at one end and leave at the other end of the spiral. If the water passes through with great velocity, and we turn the revolving mass in the direction of the arrow [i. e., so as to change the plane of the spiral], a gyroscopic force will be set up, normal to the plane of turning. Such an experiment can easily be carried out at any time. Now let us, instead of water, substitute a stream of air; the same gyroscopic forces will be set up, only proportionately less, as the mass of the air is less than that of the water. Now the rigid spiral tube and the flexible tubes have no part in the gyroscopic action, but are used only to cause the air to assume the motion it does in the cyclone. In a cyclone the centripetal forces take the place of the artificial constraints we have used in our experiments. Consequently, air currents rotating in such a manner must give rise to gyroscopic forces. Now a cyclone, though moving, preserves its shape and that of its air currents, although, as in our experiment, new air is being constantly taken in and thrown out. The amount of gyroscopic action will depend upon the mass of air in rotation and its velocity. Only the motion at right angles to the axis will be effective in this connection. The motion toward the axis will produce no gyroscopic effect. Now, for the purposes of our problem, we can substitute a solid gyroscope, producing an equivalent gyroscopic effect. This seems to me to be a rigid demonstration that the poleward acceleration of a cyclone is due simply to the gyroscopic forces generated, and I believe I am the first to have explained this phenomenon.

Now, as to Ferrel's work. This author certainly had an inkling that there were certain forces called into play setting cyclones poleward, but his demonstration mathematically of such forces was far from correct. His formula (52, quoted in the MONTHLY WEATHER REVIEW, 1903, p. 517), which gives for the accelerating force in the direction of the meridian

$$\frac{V}{M} = -\frac{g}{578}\,\frac{u \sin\phi}{n}\left(\frac{s'}{R}\right)^2,$$

is not correct. This does *not* express the acceleration northward (or southward).

I think there can be no doubt that Ferrel was not familiar with the analysis of motion of the gyroscope; and for that matter, few if any persons at that time (1857 and before) understood its motion. Professor Olmstead, late professor of natural philosophy and astronomy in Yale College, published a Natural Philosophy, I think as late as 1850, in which he refers to the gyroscope as the "mechanical paradox," and states that its motion is not understood. It was Major Barnard who gave the first clear exposition of its motion in this country. I believe, if my memory serves me right, that his book, Analysis of Rotary Motion as Applied to the Gyroscope, was written in 1859.

[1] *See* "The problem of the cyclone." Monthly Weather Review, August, 1903, p. 516.

In this book he refers to the numerous false notions that were at that time prevalent in regard to its motion. It would seem from his preface that all the explanations previously given as to how a gyroscope sustained itself against the action of gravity were incorrect. If Ferrel had understood the gyroscope, I believe he would undoubtedly have applied its analysis to the cyclone; but, failing this, his attempted demonstration that "if the fluid gyrates from right to left, the whole mass has a tendency to move toward the north," will not stand the test of examination.

As for note 5 on page 517, MONTHLY WEATHER REVIEW, 1903, I think this much can be said. The tension of the atmosphere is at all times due to the tension of the dry air plus the tension of the aqueous vapor, so that if at any time this latter tension is taken away by the condensation of the vapor into water, this must cause an inrushing of the winds to restore the equilibrium. The maintenance of the energy necessary to propel a cyclone can only be derived from the latent heat set free by precipitation, and if this constant supply of fresh energy be not forthcoming, the cyclone must soon stop on account of friction.

EXTRACT FROM THE EDITOR'S LETTER TO DOCTOR CORDEIRO.

Dated March 28, 1904.

It is a very ungracious task for an editor to publish his own notes in connection with an author's contribution to his journal. I believe that editors sometimes reject that which they do not agree with, or "edit" to suit their own ideas. In your case, I think that, as the mechanics of the atmosphere is so difficult and yet so important, I will publish a part of your letter of March 21, and invite public discussion on the subject. In general, the motions of the atmosphere can not be treated as the motions of a solid or group of solids, and nothing but the most rigorous hydrodynamics is of any real value to meteorology. Professor Ferrel's reasoning on the movements of a cyclone poleward is precisely like your own, so far as I can see. You say he was unfamiliar with the analysis of the gyroscope and that few, if any, understood the subject in 1857, and that Major Barnard was the first in this country to give a clear exposition of its motion in his memoir of 1859. I fear that you have forgotten a part of the history of our science. The gyroscope was perfectly foreshadowed by Poisson. Barnard simply put his ideas into convenient shape as a slight modification of the great problems of the top and the rotation of the earth on its axis, both of which had been discussed for a century before his time. The special case of Foucault's gyroscope was abundantly discussed in French scientific literature from 1848 to 1853, and the discussion was perfectly well known to Professor Ferrel. In fact, his very first published paper, in 1851, was a popular explanation of the gyroscope or rotascope, as it was called. His whole early life had been given to the study of the movements of bodies on the earth's surface, and it was only necessary for him to quote the equations and principles of analytical mechanics, as set forth in LaPlace's Mecanique Celeste. Major Barnard's explanation is excellent, but it is entirely wrong to say "that all the explanations previously given as to how a gyroscope sustains itself against the action of gravity were incorrect."

Your idea that "if the vapor tension in the atmosphere is diminished by the condensation of the vapor into water, this must cause an inrushing of the winds to restore the equilibrium" is as old as Hutton in England and his contemporaries in Germany; it was utterly demolished by Espy and has no place now in meterology.

Your idea that the "energy necessary to propel a cyclone can only be derived from the latent heat set free by precipitation" is that which Espy fought for all his life, and was adopted by Ferrel up to within a year of his death. Eventually, however, he saw that there is another source of energy even more important, and they both are combined in our storms. During the last fifteen years, our problem has been to get at the proper relation of these two sources of energy.

Thank you very much for your little book on hypsometry. I notice that in the preface of 1897 you state that this subject "has not been touched upon since 1851, when it was discussed by Guyot." Here, again, you ignore completely a very large and important literature.—*C. A.*

NOTES AND EXTRACTS.

METEOROLOGY IN ROUMANIA.

The last annual report of the Roumanian Meteorological Service[1] forms, as usual, a bulky folio of some 700 pages, with the text in both French and Roumanian, in parallel columns. The data for 1900 are given in considerable detail, and include for Bukharest, which alone is classed as a station of the first order, observations of ozone, evaporation, temperature of the unprotected thermometer at various heights above the ground, and temperature of the soil, but to a depth of only 120 centimeters. Observations at this station are given separately for each hour of every day for pressure, temperature, vapor pressure, relative humidity, wind direction and velocity, sunshine, solar radiation, and precipitation, with cloud observations hourly from 7 a. m. to 8 p. m. These figures are averaged for months, decades, and pentads, and the whole is recapitulated by months, seasons, years, lustrums, and decenniums, and for the whole period of observations, 1885–1900. Tridaily observations are published for 12 selected stations of the second order, with monthly and annual summaries for the entire 52 of this class, and this exhaustive collection of data is completed by the records of 340 rainfall stations.

A reduction in the station force delayed the publication of the volume until the fall of 1903. Observations are published for 1900 only, but the administration report includes in addition the two following years. There has been a steady increase in the number of stations, from 386 in 1899 to 401 in 1902, including 343 rainfall stations, and 58 regular stations, or one of the latter to each 849 square miles. While this ratio compares favorably with that in other countries, the necessity of obtaining unpaid observers has prevented the most advantageous distribution of the stations, and some important districts are almost without observations.

Dr. Stefan C. Hepites, the director of the institute, urges the establishment of a system of daily forecasts, which, he estimates, would require an increase in the annual budget of less than 20,000 francs.

[1] Analele Institutului Meteorologic al Romaniei, Tomul 16, 1900.

It is a little surprising to find that Roumania, with its agricultural interests and its favorable situation, from a meteorological standpoint, is still without this crowning feature of meteorological work.

The present volume of the Analele includes the following five memoirs:

1. La pluie en Roumanie en 1900. By St. C. Hepites.
2. Revue climatologique annuelle. Année 1900. St. C. Hepites.
3. Étude sur la crue du Jiu au mois d'Aout 1900. Em. de Martonne.
4. Observations magnetique faites à Bucuresci au cours de l'année 1900. I. St. Murat.
5. Registre des tremblements de terre en Roumanie. Année 1900. St. C. Hepites.

The precipitation over the entire kingdom averaged 662 millimeters, exceeding by more than 9 per cent the average of the preceding seventeen years, and was, as usual, most abundant in summer, when 213 millimeters fell. The distribution by altitude is shown in Table 1.

TABLE 1.

Altitude in meters.	Precipitation in millimeters.	Number of days with rain.
Below 100	591	82
100–200	665	87
200–500	698	91
Above 500	853	100

The most remarkable rainfall in Roumanian records, if intensity and amount are both considered, occurred on August 17, 1900, when 320 millimeters (12.6 inches) fell at Cara Omer between 8 p. m. and midnight, causing some damage at that and neighboring villages. Cara Omer is situated in the southeast, on the Dobrujan plateau, at an altitude of 150 meters.

The snowfall averaged 86 centimeters, amounting to 100 centimeters in the province of Moldova, where in March